Development of a New Class of Fe-3Cr-W(V) Ferritic Steels for Industrial Process Applications

Benefits

The results from this project will be used by the chemical industry in fabrication of new reactor vessels and by the steel industry in basic open hearth furnaces (BOFs) for gas-cooling hoods, and for heat recovery tubes in pulp and paper and chemical plants.

- Estimated energy saving of over 20 trillion Btu/year by 2020.

Applications

The alloys from this project are expected to have the following applications:

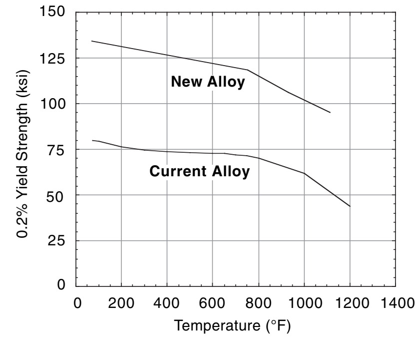
- **Chemical and Petrochemical:**
  - Hydrocrackers for the Petrochemical Industry.
  - Chemical reaction vessels for the Chemical Industries.
  - Heat recovery systems for hydrocrackers and chemical reactors.
- **Forest Products, Process Heating:** Water walls for conventional boilers.
- **Steel, Heat Treating:** Hoods for BOF furnaces for the Heat-Treating Industries.

The new ferritic alloy will lead to weight reduction, reduced fabrication time, and energy savings

The performance of materials of construction for chemical-processing equipment is often related to their high-temperature strength, low-temperature toughness, and corrosion and abrasion resistance. Among many materials of construction, Fe-2.25Cr-Mo steels find extensive use in hydrocrackers, hydrotreaters, and heat recovery systems with some of the chemical processing equipment being as large as 100 to 300 tons. During the construction of such systems with current alloys, the equipment requires postweld heat treatment (PWHT) that must be carried out in the shop environments. The requirements of PWHT limit the possibility of changes to the vessels once installed at an industrial site.

The current project focuses on the development of a new class of Fe-3Cr-W(V) steels with (a) 50% higher tensile strength than current alloys at tempertures up to 650°C, (b) potential for not requiring any PWHT, (c) 25% reduction of equipment weight, and (d) impact properties of approximately 100 ft-lb and –10°F for upper-shelf energy and ductile-to-brittle transition temperature (DBTT), respectively, without tempering treatment.

The successful implementation of Fe-3Cr-W(V) steel in chemical reactor components is estimated to result in significant energy savings of approximately 20 trillion Btu/year and cost savings of approximately $237 million/year.



Project Description

Goal: Development of a new class of Fe-3Cr-W(V) steels with (1) 50% higher tensile strength at temperatures up to 650°C than current alloys, (2) potential for not requiring any PWHT, (3) equipment weight reduction of 25%, and (4) impact properties of approximately 100 ft-lb upper shelf energy and –10°F (-20°C) for DBTT without tempering treatment.

Issues: current materials.
- Low strength properties of current alloys require thicker sections.
- Increased thickness causes heat-treatment issues related to nonuniformity across the thickness, and thus optimum properties are not achieved.
- Fracture toughness (ductile-to-brittle transition) is a critical safety issue for these vessels, and it is affected in thick sections due to nonuniformity of microstructure.
- PWHT needed after welding makes fabrication more time-consuming with increased cost.
- PWHT needed after welding limits any modifications of the large vessels in service.

Major hurdles to overcome in R&D.
- Development of new compositions.
- Microstructure correlations for optimum weld microstructures requiring no PWHT.

Approach: The project objectives will be met through a range of concepts: (1) alloy composition optimization through the use of thermodynamic/ kinetic modeling, (2) development of time-temperature-transformation curves for defining selective heat-treatment conditions, (3) melting and processing laboratory – and large-scale heats, (4) welding and fabrication process development, (5) physical and mechanical properties of base and weldments, and (6) testing of prototype components and preparation of data packages for ASTM and ASME Code approvals.

Potential payoff: The higher strength and not having to PWHT vessels fabricated with the new alloy can lead to a significant reduction in weight of large hydrocracker vessels (ranging from 100 to 300 tons) by approximately 25%, a reduction of fabrication costs, and improved in-service modification feasibility. The use of the Fe-3Cr-W(V) steels is estimated to result in an energy saving of over 20 trillion Btu/year by the year 2020.

Progress and Milestones

- Complete thermodynamic/kinetic analysis and identify alloy compositions.
- Verify thermodynamic/kinetic results on experimental-size heats.
- Complete melting of three pilot production-size heats and their properties.
- Complete welding process parameter and filler metal identification.
- Complete microstructural thermal stability.
- Complete installation of prototype components.
- Complete preparation of ASME Code package.

ORNL 2002-01496/jcn

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ExxonMobil
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January 2002